Spatial pattern of Russia's market integration

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21 February 2017

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Abstract

This paper studies integration of regional goods markets in Russia over 2001–2015 with the use of time series analysis, based on the law of one price as the criterion of market integration. The cost of a staples basket is used as a price representative. The analysis involves all pairs of country's regions, thus providing a comprehensive pattern of market integration. The region pairs are classified as belonging to one of four groups: integrated, conditionally integrated, not integrated but tending towards integration, and neither integrated nor tending towards integration. The results suggest that only less than a quarter of region pairs fall into the fourth category.

Keywords: regional goods markets, Russian regions, law of one price, price convergence

JEL classifications: L81, R15, R19

1. Introduction

A spatially separated market for a tradable good is deemed integrated if there are no barriers to trade between its spatial segments, except for ‘natural,’ geographically determined barriers, i.e. disconnectedness of the segments (quantified by transportation costs). Considering a national market, its spatial segments are regional markets (hereafter, simply regions). In the integrated market, goods arbitrage results in spatial equilibrium that manifests itself in the law of one price. In its strict form, when transportation costs may be neglected (if they are very small as compared to the price of the good or the price includes average transportation costs), the law states that the price of the same good should be equal across all regions. A weakened version of the law takes account of ‘natural’ barriers to trade, allowing the price of the good to differ between two regions by no more than transportation costs (per unit of the good). Thus, the law of one price can be applied as the criterion of market integration.

Testing for the law of one price in its strict or weakened version is a common exercise in studies of market integration. However, it overlooks an important transitional case. Despite the price differs between two regions, regional prices can converge to each other, eventually eliminating the price disparity. Thus, albeit this pair of regions is not integrated, it tends towards integration over time.

This paper analyzes time series of the cost of a staples basket over 2001–2015 with a monthly frequency across all pairs of Russian regions, providing a comprehensive pattern of market integration in the country. The region pairs are classified as belonging to one of four groups. The first one is integrated pairs, i.e. those where the strict law of one price holds. The second group is conditionally integrated pairs, where the weakened law of one price holds (the next section explains why integration is deemed conditional in this case). The third group is region pairs tending towards integration. Following a method put forward in Gluschenko (2011), the movement towards integration is modeled by a nonlinear asymptotically decaying trend of price disparity (however, unlike that paper, with the use of three different types of the trend). At last, the fourth group is neither integrated nor tending-towards-integration region pairs. The results obtained suggest that this group contains less than 24% of region pairs.

A number of papers investigate spatial pattern of market integration in Russia, using different product and location samples as well as time spans. Gardner and Brooks (1994) study market integration in Russia in 1992–1993, using data for six food commodities across 14 cities in the Volga economic area. They pool time series for all pairs of cities into a data panels (separately for each commodity). This allows including time invariant variables such as distance, price regulations, etc., but yields results averaged across city pairs, hence an overly aggregated pattern of market integration (so that its dimension disappears). Berkowitz et al. (1998) analyze time series of prices for five foods across 13 to 25 cities from the European part of Russia in 1992–1995. They do not address directly to the issue of market integration, focusing on the relationship between the behavior of prices of similar goods across cities, which provides an indirect indications of integration. Goodwin et al. (1999) consider prices for four goods across five cities of Russia during 1993–1994, analyzing linkages of prices in each pair of cities with the use of cointegration, Granger causality, and impulse response techniques. They interpret the presence of the price linkages as evidence in favor of market integration. Gluschenko (2011) uses the cost of a staples basket relative to a benchmark region across almost all regions of Russia (represented by their capital cities) over 1994–2000. Using time series analysis, regions are broken down into three groups: integrated with the benchmark region, tending towards integration with it, and neither integrated nor tending towards integration. Akhmedjonov and Lau (2012) deal with prices for four energy products in all Russian regions relative to the national average prices during 2003–2010. They focus on convergence of prices, applying time series modeling with a nonlinear trend (the argument of which is the lag of the relative price rather than time). A similar methodology is used in Lau and Akhmedjonov (2012), where convergence of aggregated (relative) prices for outer clothing across 44 regions of Russia for 2002–2009 is explored. This paper contributes to the above literature, providing a spatial pattern of market integration in Russia that involves all pairs of country's regions. (To my knowledge, such a work was not done as yet for any country with a significant number of regions.) In some respect, it supplements results of Gluschenko (2011), extending them to the 2000s.

The reminder of the paper is organized as follows. Section 2 expounds methodology applied. In Section 3, empirical data used for the analysis are described .Section 4 reports and discusses the estimation results. Section 5 compares results obtained with those for 1994–2000. Section 6 concludes.

2. Methodology

Let $p_r(t)$ and $p_s(t)$ be prices for a tradable good in regions r and s, respectively, at time point t; hereafter, $t = 0,\dots, T$. Then the strict version of the law of one price is formalized as

$$p_r(t)/p_s(t) = 1. \quad (1)$$

If relationship (1) holds for region pair (r, s), these regions are deemed integrated with each other.

The weakened version of the law of one price can be modeled as

$$p_r(t)/p_s(t) = 1 + D_{rs}, \tag{2}$$

where D_{rs} is a (percent) price disparity between regions r and s. When this relationship holds for these regions, they are deemed conditionally integrated. They could be acknowledged as integrated on condition that the disparity is due to transportation costs only. However, it can include also effects or 'artificial' impediments to integration, such as regional protectionism, local price regulations, organized crime, etc. In the framework of time series analysis, it is impossible to reveal the nature of D_{rs}, therefore the term 'conditional integration' is applied.

The movement towards integration (price convergence) is described as

$$p_r(t)/p_s(t) = 1 + D_{rs}(t), \tag{3}$$

where $D_{rs}(t)$ is an asymptotically decaying function such that $D_{rs}(t) \to 0$ as $t \to \infty$ and $\mathrm{sign}(D_{rs}(0))\cdot dD_{rs}(t)/dt < 0$. Regions in the pair ($r$, s) tend to integrate with each other, if (3) holds for it. To model price convergence, three types of trend functions are applied (to economize notation, the region indices for parameters as well as disturbances in regressions below are suppressed):

$$D_{rs}(t) = \gamma e^{\delta t}, \quad \delta < 0, \tag{4a}$$

$$D_{rs}(t) = \exp(\gamma e^{\delta t}) - 1, \quad \delta < 0, \tag{4b}$$

$$D_{rs}(t) = \exp\left(\frac{\gamma}{1+\delta t}\right) - 1, \ \delta > 0. \tag{4c}$$

An advantage of function (4a) is the ease of interpretation: γ is immediately the initial (at t = 0) price disparity; δ characterizes convergence speed in a simple way, e.g. time needed for the disparity to halve (half-life time) is computed as $\log(0.5)/\delta$. Its shortcoming is that the permutation of the region indices – from (r, s) to (s, r) – changes the values of γ and δ. In functions (4b) and (4c), initial disparity is $e^{\gamma} - 1$; half-life times depend on both δ and γ and are more complex. On the other hand, the permutation of the region indices changes only the sign of γ, keeping δ invariant.

If no one of the above three models describes the behavior of prices in region pair (r, s), these regions are deemed neither integrated nor tending towards integration with each other (hereafter, simply non-integrated for brevity).

Turning to econometrics, the log transformation is used with time being an index for prices rather than the argument of function. Then the dependent variable is the price differential $P_{rst} = \log(p_{rt}/p_{st}) = \log(p_{rt}) - \log(p_{st})$; now, $t = 1,\ldots, T$. It is natural to assume that the prices depend on their previous values, i.e. they are autocorrelated. Then the econometric version of Model (1) takes the form

$P_{rst} = \nu_t, \nu_t = (\lambda + 1)\nu_{t-1} + \varepsilon_t,$

where ν_t is the regression residual, ε_t is the white-noise random shock, and $\lambda + 1 = \rho$ is the autoregression coefficient. Substituting the second equation into the first one gives the conventional AR(1) model with no constant (ΔP_{rst} stands for the first difference, $\Delta P_{rst} \equiv P_{rst} - P_{rs,t-1}$):

$$\Delta P_{rst} = \lambda P_{rs,t-1} + \varepsilon_t. \quad (5)$$

Similarly, the econometric counterpart of Model (2) is the AR(1) model with constant $\alpha = -\lambda \log(1 + D_{rs})$:

$$\Delta P_{rst} = \alpha + \lambda P_{rs,t-1} + \varepsilon_t. \quad (6)$$

The econometric version of model (3) looks like

$$\Delta P_{rst} = h(t) - (\lambda + 1)h(t - 1) + \lambda P_{rs,t-1} + \varepsilon_t. \quad (7)$$

In this equation, $h(t)$ denotes a trend of the price differential, $h(t) = \log(1 + D_{rs}(t))$. This trend tends to zero, as time tends to infinity; its initial value is P_{rs0}. Under such transformation, we have instead (4a)–(4c) the following trends (respectively):

log-exponential trend $h(t) = \log(1 + \gamma e^{\delta t},)\ \ \delta < 0,$ (8a)

exponential trend $h(t) = \gamma e^{\delta t},\ \ \delta < 0,$ (8b)

fractional trend $h(t) = \gamma/(1 + \delta t),\ \delta > 0.$ (8c)

A problem in exploring spatial market integration is a great number of region pairs, equaling $N(N - 1)/2$. For instance, 79 Russian regions produce 3081 pairs. There are a few ways to reduce dimensionality. The first is to pool time series of all region pairs into a data panel, estimating only one panel regression, as, e.g., Gardner and Brooks (1994) do. However, this yields only a characterization of the whole market with no geographical dimension. Another way is to use some region as a benchmark, i.e. to fix some region index, say, s in regressions (5)–(7), as, e.g., in Gluschenko (2011). Then the number of pairs (hence, regressions) equals $N - 1$. Seemingly, this way would provide a comprehensive spatial pattern of integration, since only $N - 1$ of all pairs are independent, making it possible to generate a time series for any other region pair, e.g., $P_{qrt} = P_{qst} - P_{rst} = \log(p_{qt}) - \log(p_{st}) - (\log(p_{rt}) - \log(p_{st}))$. But, unfortunately, autocorrelation of time series leads to non-transitivity of statistical inference. For instance, if region pairs (q, s) and (r, s) are integrated, i.e. each satisfy Equation (5), this does not imply that pair (q, r) is also integrated. And vice versa, despite P_{qst} and P_{rst} are unit root processes (random walks), P_{qrt} may manifest regularity of form (5)–(7). Thus, we have only a partial spatial pattern which suggests integration with the benchmark region, but is silent as to integration of other region pairs. A consequence is that the pattern obtained crucially depends on the choice of benchmark region. One more way is to use the national market as the benchmark; that is, the national price (a weighted average of regional prices) serves as the numeraire, like, e.g., in Akhmedjonov and Lau (2012). Here, the same problem of non-transitivity as above arises. Besides, this way is questionable from the econometrical viewpoint, since price differentials involve a mixture of all regional prices. Some of them could be unit root processes, spoiling the whole pattern of market integration.

Thus, the existing ways of reducing the number of pairs do not provide a comprehensive pattern of market integration. Therefore regressions (5)–(7) are estimated and tested separately for each region pair (r, s) over t = 1,…, T. The most important hypothesis to be tested is whether time series P_{rst} has a unit root, H_λ: $\lambda = 0$ (against $\lambda < 0$). Its rejection implies that the time series is stationary, fluctuating around its long-run path. Intuitively this means that when a random shock forces the price differential to deviate from the long-path, market forces return it (after a time) back. Otherwise, if the time series is non-stationary, no return occurs. The long-run path is the price parity, $P^* = 0$, in Model (5), and a time-invariant constant, $P^* = \log(1 + D_{rs})$, in Model (6). In the case of Model (7), the long-run path is one of the above trends $h(t)$. To test for a unit root, the augmented Dickey-Fuller test and Plillips-Perron test are applied. The hypothesis of non-stationarity is rejected if both tests reject it at the level of 10%. (For technical details of testing, see Appendix).

Given that H_λ is rejected, statistical significance of the rest parameters – α in (6) and γ and δ in (7) – is tested with the use of the conventional t-test at the 10% level. Three varieties of Equation (7) are estimated (with each trend). Of them, the variety providing the best fit – namely, the minimal sum of squared residuals – is accepted. It is possible in the case of Model (7) that it is significant, but $\delta > 0$ in trends (8a) or (8b), or $\delta < 0$ in trend (8c). This implies price divergence, hence the respective region pair is deemed non-integrated.

Not infrequently, a time series P_{rst} satisfies more than one model from their set (5)–(7). Then the ‘most proper’ model is to be selected. Two approaches are possible, general to specific and specific to general. The general model in this set is (7). It encompasses the rest models: imposing restriction $\delta = 0$ on $h(t)$ of the form (8a)–(8c), we get Equation (6), and $\gamma = 0$ produces Equation (5). Then the analysis of a time series goes from the general Equation (7) to Equation (6) and then to (5), accepting the first significant model in this sequence.

Albeit the general-to-specific approach seems attractive from the theoretical point of view, the specific-to-general approach (which implies the reverse sequence) is applied here, based on the following intuitive considerations. If a time series satisfies both Equations (5) and (6), it is reasonable to assume that although constant α in Equation (6) is statistically significant, it is small and is caused by some accidental reasons (being a statistical artifact) rather than by properties of the process itself. Hence, it is logical to accept Model (5). Similarly, when a time series satisfies both Equations (6) and (7), the reason is a very weak trend, maybe, incidentally manifesting itself in the data. Hence, the model without trend, Equation (6), should be accepted. A random inspection of some such cases has confirmed these assumptions.

3. Data

The Russian Federation consists of constituent units (republics, *oblasts*, one autonomous *oblast*, *krais*, autonomous *okrugs*, and federal cities) termed federal subjects. Despite different designations, all these are equal in legal terms. There is a curious feature of the political division of Russia, 'composite' federal subjects, namely, *oblasts* or *krais* that include one or more other federal subjects, autonomous *okrugs*. (The Chukchi Autonomous Okrug is the only one that is not a part of another federal subject.) Within the time span under consideration, the autonomous *okrugs* have been merging with the *oblasts*/*krais* that include them, ceasing to be separate federal subjects (by now, only two 'composite' federal subjects remain).

In this study, by a region is meant a federal subject (including federal cities of Moscow and Saint Petersburg); however, the composite federal subjects are considered as single regions (namely, the Arkhangelsk, Tyumen, and Irkutsk *oblasts*, and the Transbaikal and Kamchatke *krais*). The spatial sample for the analysis covers 79 regions, all Russia's regions but the Chechen Republic (as well as the Republic of Crimea and the city of Sevastopol), where full data on prices are lacking. They generate 3081 region pairs.

An aggregated market for 33 basic foods (staples) is considered, using the cost of a basket of these goods as a price representative for the analysis. Rosstat (2005, Appendix 6)[1] reports the composition of the basket. The analysis covers January 2001 through December 2015 with a monthly frequency (180 time observations). The price data are drawn from the Integrated Interagency Informational and Statistical System of Russia (EMISS), https://www.fedstat.ru/indicator/31481.do.

Figure 1 reports summary statistics – the mean and standard deviation – of the price differentials over the time span under consideration. The sign of the price differential depends on the order of regions in their pair; therefore a rearrangement of region indexes can change the summary statistics. To avoid this effect, the summary statistics are computed for the absolute values of the

[1] Available on http://www.gks.ru/free_doc/new_site/prices/potr/PRIL6.DOC

price differentials, $|P_{rst}|$.

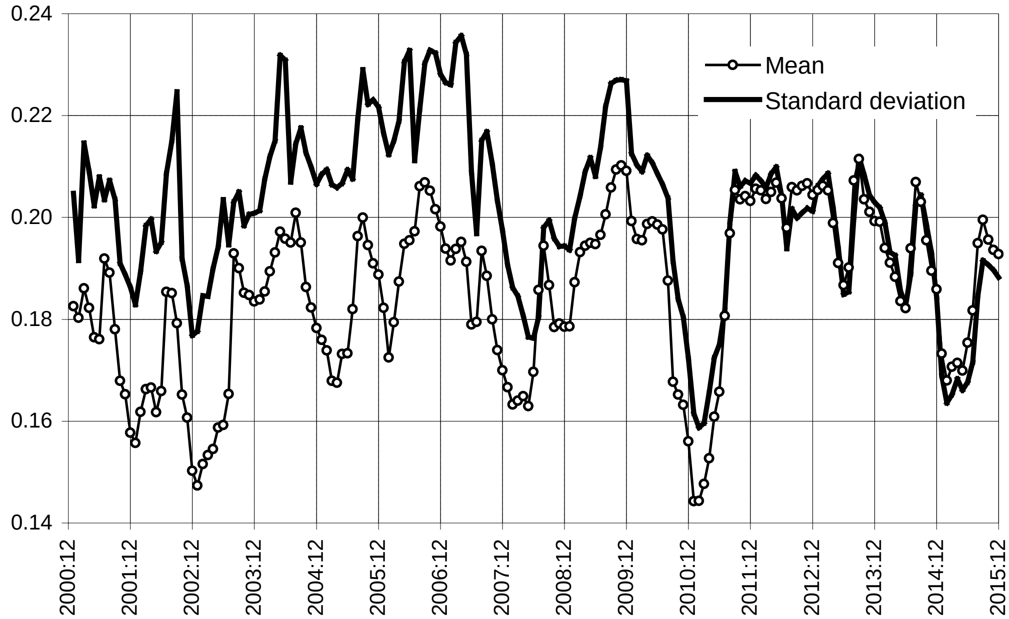
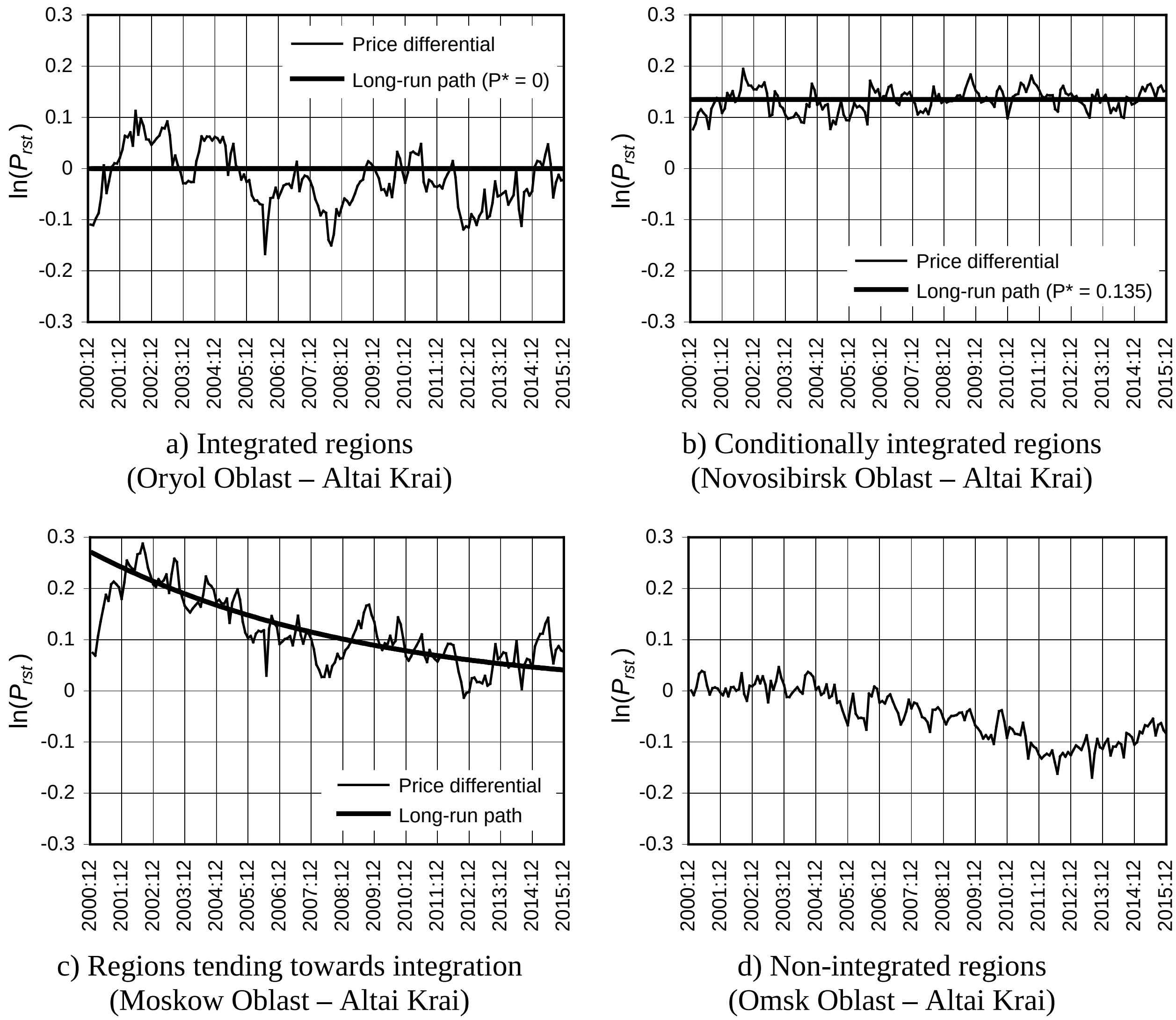


Figure 1. Summary statistics of absolute price differentials.

Statistics depicted in Figure 1 give an idea of price dispersion in the Russian spatial market. As it is seen, the price dispersion is highly volatile with dramatic fluctuations; the maximum to minimum ratio equals about 1.5 for both mean and standard deviation. This is due to relatively high inflation that greatly differs across regions. On average, monthly inflation rate over 2001–2015 was 0.85% (10.7% per year), varying across regions from 0.71% to 0.96% (8.9% to 12.1% per year). Over time, the mean of the absolute price differential tends to increase, while its standard deviation tends to decrease. Assuming a linear trend, the former rises by 0.8% per year, and the latter falls by 0.6% per year. Thus, it can be concluded that the process of spatial market integration in Russia is not completed. It is still in transition; both price convergence and divergence are going on in some spatial parts of the market. This makes analyzing only the state of integration with models of the form (5) or/and (6) insufficient, which motivates the use of modeling the movement to integration.

4. Empirical results

Before presenting full results, it is instructive to look at an example of specific region pairs belonging to each of four groups: integrated, conditionally integrated, tending towards integration, and non-integrated. Figure 2 illustrates these, depicting the actual evolution of the price differentials vs. their theoretical long-run paths. No long-run path exists for the non-integrated pair, Figure 2d.



a) Integrated regions
(Oryol Oblast – Altai Krai)

b) Conditionally integrated regions
(Novosibirsk Oblast – Altai Krai)

c) Regions tending towards integration
(Moskow Oblast – Altai Krai)

d) Non-integrated regions
(Omsk Oblast – Altai Krai)

Figure 2. Examples of four types of region pairs.

Figure 2 clarifies econometric considerations in the previous section. Equation (5) holds for the pair of integrated regions, Figure 2a. The price differential fluctuates around the price parity line $P^* = 0$; that is, prices in these regions continually tend to equalize with each other. The conditionally integrated pair in Figure 2b satisfies Equation (6). Here, the price differential fluctuates around some nonzero constant. This means that prices in these regions tend to maintain a constant price disparity, 14.4% (on average) in real terms. Regions in Figure 2c are moving to integration with each other. This pair satisfies Equation (7) with trend $h(t) = 0.273e^{-0.010t}$. Over time, the price differential diminishes, approaching the parity. Certainly, this does not imply that it necessarily will reach the parity. It is possible that beyond the time span under consideration the price differential will come to some equilibrium disparity. At last, no one model describes the behavior of price differential in

Figure 2d. It is interestingly to note that while the Altai Krai is integrated with the Oryol Oblast and not integrated with the Omsk Oblast, the Oryol and Omsk *oblasts* are conditionally integrated with each other, having $P^* = 0.035$ that corresponds to a 3.6% price disparity in real terms.

Table 1 tabulates the results of analysis across all region pairs in a summarized form. For each region, it reports percentage of the rest 78 regions with which the given region is integrated, conditionally integrated, tending towards integration, and not integrated (and not tending towards integration). In the last case, non-integration can be caused by price divergence, which manifests itself in a positive trend factor in trends (8a) and (8b) or negative factor in trend (8c). The percentage of such cases is also reported. In fact, the actual cases of divergence may be greater, as trends of the form (8a)–(8c) cannot cross zero by construction. Therefore Equation (7) cannot detect divergence with a trend crossing zero. The last line in the table reports the total percentage of respective region pairs (among all 3081 pairs).

Table 1. Results of the analysis: the pattern of Russia's market integration (in percentage terms)

Region	Integrated with	Conditionally integrated with	Tending towards integration with	Not integrated with	Diverging with
1. Rep. of Karelia	15.4	65.4	5.1	14.1	7.7
2. Rep. of Komi	16.7	57.7	2.6	23.1	12.8
3. Arkhangelsk Obl.	16.7	29.5	2.6	51.3	33.3
4. Vologda Obl.	16.7	53.8	5.1	24.4	11.5
5. Murmansk Obl.	9.0	65.4	11.5	14.1	2.6
6. St. Petersburg City	11.5	50.0	5.1	33.3	11.5
7. Leningrad Obl.	20.5	57.7	5.1	16.7	11.5
8. Novgorod Obl.	25.6	64.1	1.3	9.0	5.1
9. Pskov Obl.	17.9	17.9	10.3	53.8	37.2
10. Kaliningrad Obl.	16.7	46.2	2.6	34.6	6.4
11. Bryansk Obl.	30.8	48.7	3.8	16.7	3.8
12. Vladimir Obl.	33.3	47.4	1.3	17.9	5.1
13. Ivanovo Obl.	28.2	28.2	7.7	35.9	7.7
14. Kaluga Obl.	26.9	20.5	11.5	41.0	14.1
15. Kostroma Obl.	43.6	48.7	1.3	6.4	5.1
16. Moscow City	10.3	23.1	24.4	42.3	2.6
17. Moscow Obl.	21.8	43.6	6.4	28.2	9.0
18. Oryol Obl.	44.9	42.3	3.8	9.0	3.8
19. Ryazan Obl.	34.6	33.3	1.3	30.8	19.2
20. Smolensk Obl.	24.4	59.0	3.8	12.8	6.4
21. Tver Obl.	26.9	44.9	2.6	25.6	7.7
22. Tula Obl.	29.5	43.6	2.6	24.4	7.7
23. Yaroslavl Obl.	26.9	39.7	5.1	28.2	20.5
24. Rep. of Mariy El	29.5	46.2	2.6	21.8	6.4
25. Rep. of Mordovia	33.3	37.2	0	29.5	16.7
26. Chuvash Rep.	29.5	50.0	2.6	17.9	3.8
27. Kirov Obl.	41.0	39.7	0	19.2	14.1
28. Nizhni Novgorod Obl.	28.2	47.4	0	24.4	15.4

Region	Integrated with	Conditionally integrated with	Tending towards integration with	Not integrated with	Diverging with
29. Belgorod Obl.	28.2	41.0	0	30.8	24.4
30. Voronezh Obl.	50.0	34.6	0	15.4	6.4
31. Kursk Obl.	9.0	12.8	0	78.2	51.3
32. Lipetsk Obl.	19.2	61.5	1.3	17.9	15.4
33. Tambov Obl.	23.1	62.8	3.8	10.3	3.8
34. Rep. of Kalmykia	25.6	24.4	20.5	29.5	1.3
35. Rep. of Tatarstan	25.6	43.6	5.1	25.6	7.7
36. Astrakhan Obl.	28.2	38.5	5.1	28.2	9.0
37. Volgograd Obl.	42.3	39.7	0	17.9	9.0
38. Penza Obl.	25.6	39.7	0	34.6	24.4
39. Samara Obl.	26.9	38.5	14.1	20.5	7.7
40. Saratov Obl.	20.5	11.5	0	67.9	25.6
41. Ulyanovsk Obl.	26.9	43.6	1.3	28.2	15.4
42. Rep. of Adygeya	48.7	43.6	1.3	6.4	2.6
43. Rep. of Dagestan	37.2	30.8	3.8	28.2	6.4
44. Rep. of Ingushetia	56.4	30.8	1.3	11.5	5.1
45. Kabardian-Balkar Rep.	43.6	48.7	0	7.7	5.1
46. Karachaev-Cirkassian Rep.	51.3	41.0	2.6	5.1	1.3
47. Rep. of Northern Ossetia	32.1	47.4	6.4	14.1	6.4
48. Krasnodar Krai	30.8	44.9	5.1	19.2	10.3
49. Stavropol Krai	39.7	39.7	1.3	19.2	9.0
50. Rostov Obl.	33.3	30.8	2.6	33.3	5.1
51. Rep. of Bashkortostan	30.8	41.0	5.1	23.1	3.8
52. Udmurt Rep.	42.3	35.9	1.3	20.5	2.6
53. Kurgan Obl.	33.3	46.2	5.1	15.4	7.7
54. Orenburg Obl.	25.6	46.2	0	28.2	5.1
55. Perm Krai	34.6	47.4	2.6	15.4	6.4
56. Sverdlovsk Obl.	24.4	60.3	3.8	11.5	6.4
57. Chelyabinsk Obl.	44.9	43.6	1.3	10.3	7.7
58. Rep. of Altai	35.9	38.5	6.4	19.2	15.4
59. Altai Krai	42.3	39.7	12.8	5.1	0
60. Kemerovo Obl.	46.2	39.7	0	14.1	9.0
61. Novosibirsk Obl.	21.8	37.2	7.7	33.3	19.2
62. Omsk Obl.	33.3	53.8	0	12.8	10.3
63. Tomsk Obl.	34.6	41.0	6.4	17.9	5.1
64. Tyumen Obl.	10.3	67.9	12.8	9.0	1.3
65. Rep. of Buryatia	35.9	38.5	2.6	23.1	9.0
66. Rep. of Tuva	34.6	57.7	1.3	6.4	6.4
67. Rep. of Khakasia	43.6	50.0	0	6.4	6.4
68. Krasnoyarsk Krai	19.2	64.1	2.6	14.1	2.6
69. Irkutsk Obl.	35.9	53.8	1.3	9.0	5.1
70. Transbaikal Krai	33.3	56.4	1.3	9.0	5.1
61. Rep. of Sakha (Yakutia)	0	79.5	3.8	16.7	9.0
72. Jewish Autonomous Obl.	6.4	51.3	2.6	39.7	7.7
73. Chukotka A.O.	0	46.2	48.7	5.1	0
74. Primorsky Krai	1.3	35.9	5.1	57.7	41.0
75. Khabarovsk Krai	1.3	30.8	2.6	65.4	53.8
76. Amur Obl.	11.5	33.3	2.6	52.6	25.6
77. Kamchatka Krai	1.3	79.5	19.2	0	0
78. Magadan Obl.	1.3	50.0	1.3	47.4	34.6
79. Sakhalin Obl.	0	56.4	6.4	37.2	3.8
Total	26.8	44.6	4.7	23.8	11.0

Obl. = Oblast, Rep. = Republic, and A.O. = Autonomous Okrug.

Among all region pairs, 71% are integrated or conditionally integrated. Adding pairs tending towards integration, we get the total of 76%. Based on this figure, it seems that the state of spatial market integration in Russia can be deemed satisfactory. Unfortunately, there is no possibility to immediately compare these results with other countries, since so far a similar analysis has not been performed for any country. An indirect comparison can be done with results due to Ceglowski (2003), who applies a model of form (6) to analyze prices for 45 individual goods across 25 cities in Canada (using Ottawa as a benchmark city). Averaging results reported in Ceglowski (2003, Table 2) over all covered goods, the percentage of cities integrated and conditionally integrated with Ottawa equals 55%.

Given long distances between many regions of Russia and supposing that constant price disparities are due to transportation costs only, it is reasonable to expect that conditional integration would prevail. That is, indeed, the case; the number of conditionally integrated region pairs is 1.7 times greater than the number of 'strictly' integrated ones. Nonetheless, the latter is substantial, 27% of the region pairs. Figure 3 plots distributions of the degree of integration (left panel) and degree of integration and conditionally integration in total (right panel) in the form of histograms. The degree of integration (etc.) is the percentage of regions that are integrated (etc.) with a given one. Herefrom, $[x, y)$ is the interval within which a percentage, Z, lies: $x \le Z < y$.

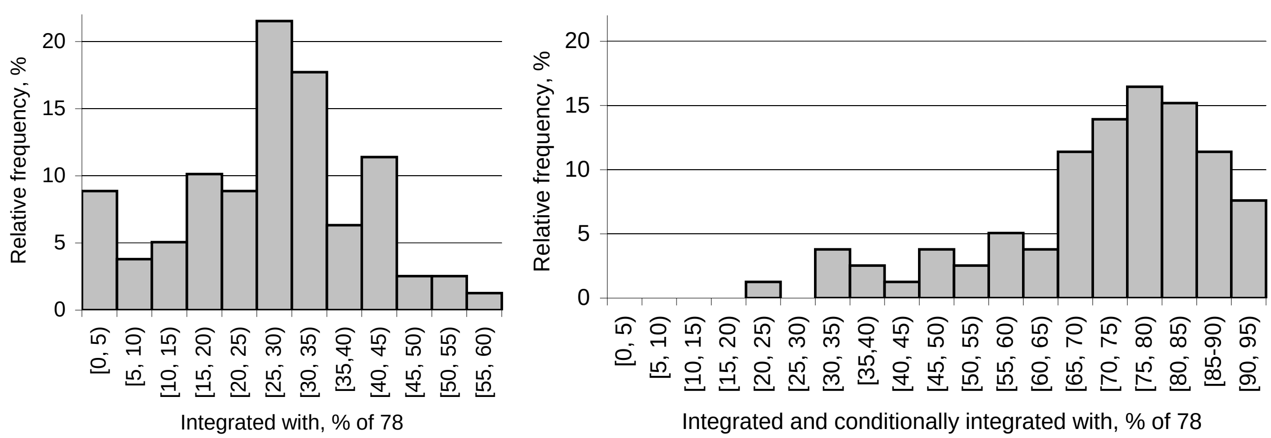


Figure 3. Distributions of the degree of integration and degree of both 'strict' and conditional integration.

The histogram bar [0, 5) in the left panel of Figure 3 suggests that there are 8.9% of regions (7 regions of 78) integrated with 0% to less than 5% of other regions. The most frequent case is integration with 25% to 30% of other regions; there are 21.5% of such cases. No one region is integrated with more that 60% (in fact, 56.4%) of other regions. Turning to the sum of integrated and conditionally integrated regions (the right panel of Figure 3), the 'worst' case is 20% to 25%; hence there are no regions without conditional integration with other ones. In most cases (75.9%[2]), regions are integrated, 'strictly' and conditionally, with 65% to 95% of other regions. Specific regions that determine the left-most and right-most bars in these and next histograms will be named below.

Processes of price convergence, i.e. the movement towards integration, do take place in the Russian market. However, they are relatively rare, occurring only in 5% of region pairs. Figure 4 plots distribution of the degree of tending towards integration. The most cases are concentrated in the range of 0 to 5%, making up 64.6%. Of them, cases of no convergence give17.9%; price convergence with one region gives 19.2%. The only region (1.3%) tends towards integration with a great number – namely, 48.7% – of other regions.

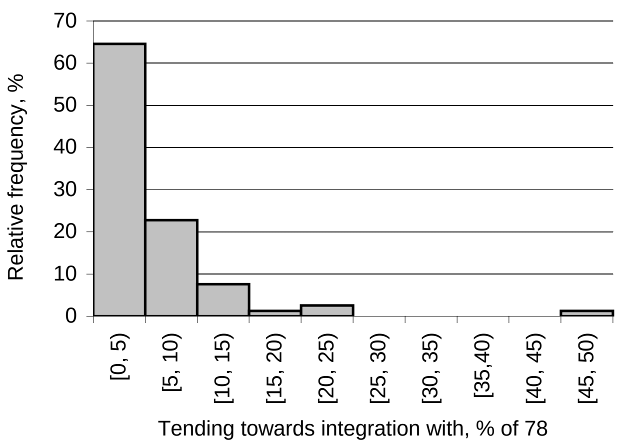


Figure 4. Distribution of the degree of tending towards integration.

Almost a quarter of region pairs are classed as non-integrated. Recall that non-integration means that a region pair not only is not integrated, 'strictly' or conditionally, but also does not tend towards integration. The left panel of Figure 5 plots the distribution of the degree of non-integration. There is only one region with this degree equaling 0 (it is the only region in the range of 0 to 5%). The most frequent case (19%) is non-integration with 15% to 20% of other regions. The range of the degree of non-integration is very wide, running to 78.2%.

[2] Note that each region is herein taken twice, in pair (*r*, *s*) and (*s*, *r*). That is why this figure exceeds the total percentage of integrated and conditionally integrated pairs.

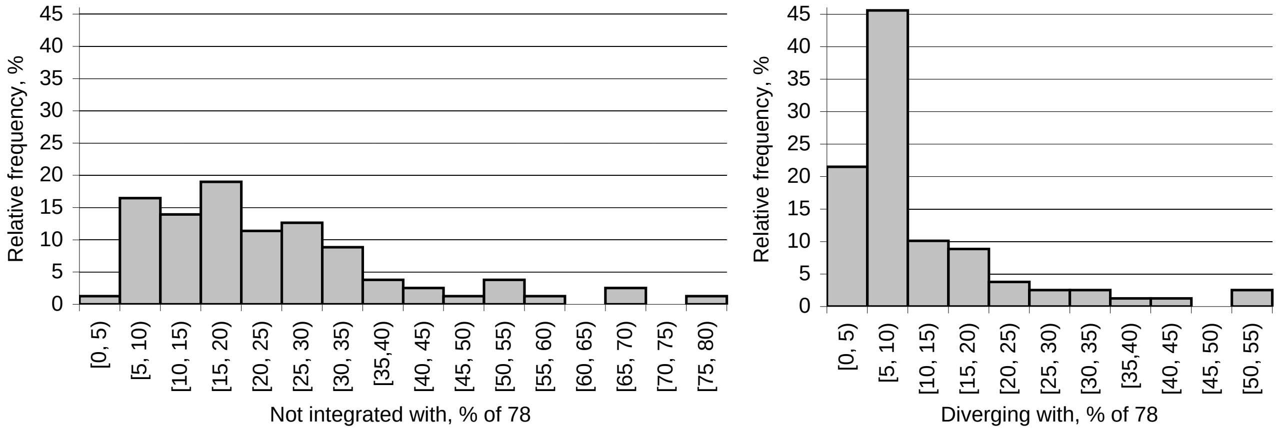


Figure 5. Distributions of the degree of non-integration and degree of divergence.

An unpleasant feature of non-integration is significant abundance of price divergence. As mentioned above, the number of cases of divergence may actually be more, since only those are detected that satisfy Equation (7) with incorrect sign of estimated parameter δ. The cases of divergence are more than twice as much as the cases of convergence. Price divergence is responsible for 46% of non-integration. The right panel of Figure 5 plots the distribution of the degree of divergence. Only three regions do not diverge with any one other. The most frequent case is price divergence with 5% to 10% of regions; it occurs in a bit less than a half (45.6%) of regions. About a third of regions (32.9%) diverge with a greater number of other regions, up to 53.8% of them.

Figure 6 relates the results to geography, mapping ‘integration rates’ of regions, that is, the total percentage (as a range) of regions with which a given region is integrated, conditionally integrated, and tends towards integration. Note that the ‘integration rate’ is reverse to the degree of non-integration (column “Not integrated with” in Table 1 and the left panel of Figure 5), equaling 100% minus this degree.

The European part of Russia comprises 57 regions westward from the Tyumen Oblast (numbered as 64); the rest – 22 regions – is the Asian part of the country. In turn, it consists of Siberia and the Russian Far East. Siberia comprises regions from the Tyumen Oblast (including it) eastward up to the western border of Yakutia (region 71) and the Amur Oblast (region 76). Regions to the east of this border belong to the Russian Far East. Taking a look at the map, some unexpected features are seen. Given much shorter distances and more developed transport infrastructure in the European part of Russia than in its Asian part, one would a priory expect the former to be more strongly integrated than the latter. However, a significant number of poorly integrated regions are present in the European part. Except for the northern Arkhangelsk Oblast (region 2) and the exclave

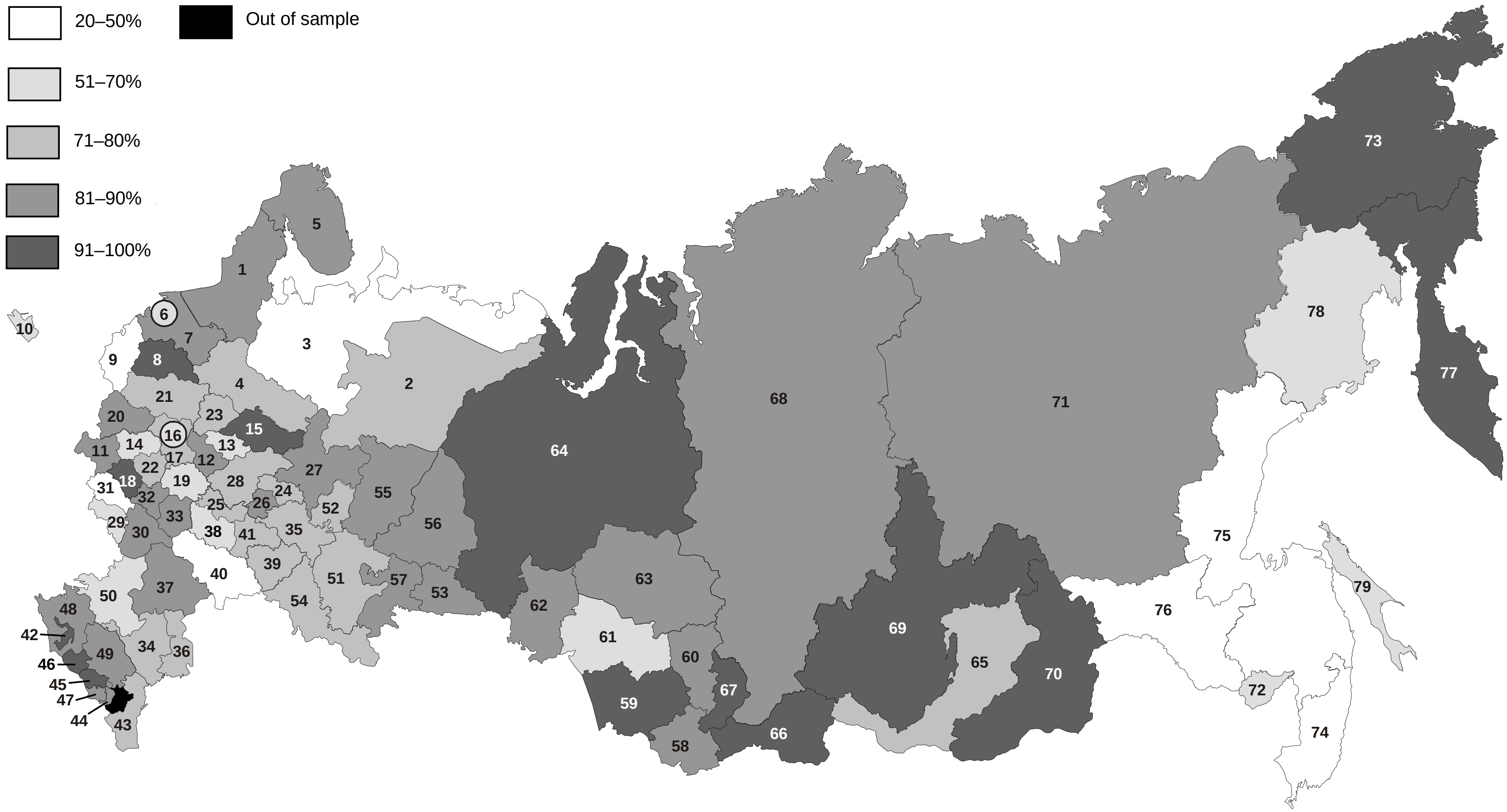


Figure 3. Geography of market integration in Russia: 'integration rates' for country's regions.

See Table 1 for numerical designations of regions.

Kaliningrad Oblast (region 10), the rest cases can be hardly explained by geographical reasons. At the same time, integration in Siberia is fairly strong; there is the only region with the ‘integration rate’ below 70% (the Novosibirsk Oblast, region 61); many regions have the ‘integration rate’ above 90%. Poor integration of Far Eastern regions is quite expectable. Surprisingly, the most remote in Russia and difficult-to-access regions, Chukotka (region 73) and Kamchatka (region 77) have ‘integration rates’ exceeding 90%.

Table 2 lists the ‘best’ and ‘worst’ regions with respect to different aspects of market integration. Values are expressed in percentage (of 78 regions).

Table 2. Ranking of regions by different indicators of market integration

The most integrated region	Integrated with	The least integrated region	Integrated with
44. Rep. of Ingushetia	56.4	61. Rep. of Sakha (Yakutia)	0
46. Karachaev-Cirkassian Rep.	51.3	73. Chukotka A.O.	0
30. Voronezh Obl.	50.0	79. Sakhalin Obl.	0
42. Rep. of Adygeya	48.7	74. Primorsky Krai	1.3
60. Kemerovo Obl.	46.2	75. Khabarovsk Krai	1.3
18. Oryol Obl.	44.9	77. Kamchatka Krai	1.3
57. Chelyabinsk Obl.	44.9	78. Magadan Obl.	1.3
The most integrated and conditionally-integrated region	**Integrated and conditionally integrated with**	**The least integrated and conditionally-integrated region**	**Integrated and conditionally integrated with**
67. Rep. of Khakasia	93.6	31. Kursk Obl.	21.8
15. Kostroma Obl.	92.3	40. Saratov Obl	32.1
42. Rep. of Adygeya	92.3	75. Khabarovsk Krai	32.1
45. Kabardian-Balkar Rep.	92.3	16. Moscow City	33.3
46. Karachaev-Cirkassian Rep.	92.3	9. Pskov Obl.	35.9
66. Rep. of Tuva	92.3	74. Primorsky Krai	37.2
8. Novgorod Obl.	89.7	76. Amur Obl.	44.9
69. Irkutsk Obl.	89.7	3. Arkhangelsk Obl.	46.2
70. Transbaikal Krai	89.7	73. Chukotka A.O	46.2
The least non-integrated region	**Not integrated with**	**The most non-integrated region**	**Not integrated with**
77. Kamchatka Krai	0	31. Kursk Obl.	78.2
46. Karachaev-Cirkassian Rep.	5.1	40. Saratov Obl	67.9
59. Altai Krai	5.1	75. Khabarovsk Krai	65.4
73. Chukotka A.O.	5.1	74. Primorsky Krai	57.7
15. Kostroma Obl.	6.4	9. Pskov Obl.	53.8
42. Rep. of Adygeya	6.4	76. Amur Obl.	52.6
67. Rep. of Khakasia	6.4	3. Arkhangelsk Obl.	51.3
66. Rep. of Tuva	6.4	78. Magadan Obl.	47.4

Obl. = Oblast, Rep. = Republic, and A.O. = Autonomous Okrug.

The data in the upper panel of Table 2 look reasonable. Regarding its left part, the most integrated regions are from the European part of Russia, except for the Kemerovo Oblast from

Siberia. The rightmost histogram bar in the left panel of Figure 3 is due to Ingushetia; the next four regions form two preceding bars. As for the least integrated regions, all they are remote Far Eastern regions; hence, ‘strict integration’ (with no price disparities with other regions) can occur in rare cases. It is these seven regions that form the leftmost histogram bar in the left panel of Figure 3.

Six first regions in the left part of the middle panel of Table 2 form the rightmost histogram bar in the right panel of Figure 3. Interestingly, the first region here is from Siberia. There are two more Siberian regions in the list, and even one from the Far East. Thus, about a half of regions integrated or conditionally integrated with the most number of other regions are from the Asian part of Russia. Turning to the right part of this panel, the presence of Far Eastern regions as well as the northern Arkhangelsk Oblast looks reasonable. However, four regions here are from the European part of the country. The ‘worst’ is the Kursk Oblast (the leftmost histogram bar in the right panel of Figure 3 is due to it only). This is quite unexplainable, the more so as the Kursk Oblast is adjacent to the Oryol Oblast (region 18) which is integrated/conditionally integrated with 87.2% of regions and is among regions with the highest ‘integration rate.’ The same relates to the Saratov and Pskov *oblasts* surrounded by strongly integrated regions. The situation with Moscow is more or less understandable. The Moscow market is known for many and varied impediments to access to the market, at least in the early 2000s.

The lower panel of Table 2 deals with the absence of integration (‘strict’ and conditional) and the movement to it, which is reverse to the ‘integration rate.’ Kamchatka turns out to be the best in this respect (and forms the leftmost histogram bar in the left panel of Figure 5). This is due to the fact that Kamchatka is integrated (in one case) and conditionally integrated with 81% of regions and tends towards integration with 19% of rest regions. The case of Chukotka, the most eastern region of Russia, is also interesting. Albeit it is conditionally integrated with only 46% of regions, it tends towards integration with 49% of regions (determining the rightmost histogram bar in Figure 4). This results in a very high ‘integration rate,’ 95%.

Of the eight ‘worst’ regions in the right part of the lower panel of Table 2, seven are the same as in its middle panel, the top three coinciding. Moscow is not present here because of convergence with 24% of regions. Instead, the Magadan Oblast appears that converges with only one region. No one case of price convergence with other regions is observed in the Kursk and Saratov *oblasts* (it is the Kursk Oblast that forms the rightmost histogram bar in the left panel of Figure 5). Convergence with two regions occurs in the Khabarovsk Krai, and Amur and Arkhangelsk *oblasts*. The Primorsky Krai and Pskov Oblast converge with four and eight regions, respectively. Contrastingly, price divergence is widespread among these regions; they diverge with 25.6% to 53.8% of regions.

Regions listed in the right part of the lower panel of Table 2 are at the same time those with maximum cases of price divergence. The Kursk Oblast and Khabarovsk Krai form the rightmost histogram bar in the right panel of Figure 4, diverging with more than a half of regions.

5. 2001–2015 vs. 1994–2000

As it is mentioned in Introduction, Gluschenko (2011) reports a spatial pattern of market integration in Russia in 1994–2000. It is interesting to compare this with the pattern obtained for 2001–2015, albeit these two analyses are not fully comparable. Firstly, they differ in data used. For 1994–2000, the cost of a staples basket consisting of 25 foods has been analyzed, while the 33-food basket is used here. The difference is not only in the number of goods, but also in their quantities across the baskets. Secondly, the price data for 1994–2000 are those collected in capital cities of regions, whereas the data for 2001–2015 are regional averages (to be exact, averages over cities/ towns where prices are being observed by the official statistics in a given region). Secondly, the 1994–2000 analysis covers 75 regions (2775 region pairs); it does not include the Moscow and Leningrad *oblasts*, Ingushetia, and Chukotka. Thirdly, the analyses differ in methodology. The analysis for 1994–2000 uses a benchmark region, exploits general-to-specific approach, and classes conditionally integrated pairs as non-integrated (since most price disparities were so great that could not be assigned to transportation costs only). However, Table A2 in Gluschenko (2011) reports results of estimation across all region pairs for selection of the 'best' benchmark region.[3] Besides, benefiting from unpublished intermediate results of the 1994–2000 analysis, it is possible to make the methodologies comparable. Table 3 compares summarized patterns obtained for 1994–2000 and 2001–2015 within the framework of both specific-to-general and general-to-specific approaches.

Table 3. Comparison of integration patterns for 1994–2000 and 2001–2015, percentage of region pairs

Group of region pairs	Specific to general		General to specific	
	1994–2000	2001–2015	1994–2000	2001–2015
Integrated	54.7	26.8	25.8	8.6
Conditionally integrated	29.2	44.6	32.6	30.7
Tending towards integration	11.3	4.7	34.3	18.4
Total	**95.2**	**76.2**	**92.7**	**57.7**
Non-integrated	4.8	23.8	7.3	42.3
Diverging	1.1	11.0	3.6	29.5

[3] It is worth noting that the Saratov Oblast was chosen, as it generated the greatest number of integrated region pairs. In 2001–2015, this region turns out to be the second 'worst.' This is one more argument against the benchmark approach.

There is a great difference between the periods of 1994–2000 and 2001–2015. Prior to 1992, the overwhelming part of consumer prices in Russia was centrally-fixed; in January 1992, they were liberalized (decontrolled). However, no market institutions existed by that time; the wholesale trade and the most part of retail trade were state-owned. Such institutions were emerging during the early 1990s due to mass privatization and market self-organization. As a result, spatial goods arbitrage came into play since about 1994; beginning in that year, improvement in integration of Russia's regional market was observed. The period of 1994–2000 was that of further transition from centrally-planned to market economy; 'artificial' barriers to inter-regional trade becoming progressively lowered (Gluschenko, 2010). In 2001–2015, by contrast, the Russian economy was functioning as a market one; at least, there were no fundamental differences in the functioning of markets for consumer goods in Russia and long-standing market economies.

Therefore, one would expect integration in 1994–2000 to be poorer than in 2001–2015 (with a greater number of region pairs tending towards integration). Surprisingly, this is not the case. The 'integration rate' in 1994–2000 is significantly higher, exceeding 90% under both approaches. The use of the general-to-specific approach decreases the 'integration rate' by only 2.5 percent points. If this approach would be applied to obtain the 2001–2015 pattern, the 'integration rate' dropped by 18.5 percent points, to 58%. As expected, the share of region pairs tending towards integration is greater in 1994–2000. However, this is not the reason for higher 'integration rate;' the share of integrated and conditionally integrated pairs is also greater in 1994–2000: 86.6% as compared to 71.4% in 2001–2015 (58.4% vs. 39.3%, respectively, under the general-to-specific approach). The most unexpected is widespread 'strict' integration in 1994–2000. The percentage of integrated pairs in that period is twice (or even three times) as much as in 2001–2015. The cases of prices divergence were rare in 1994–2000. In the next period, their number dramatically increased, up to almost one third, if additional 18.5% of region pairs exhibiting weak divergence trends (revealed by the general-to-specific approach) were taken into consideration.

Possibly, unexpected features in the difference between the 1994–2000 and 2001–2015 patterns can be partially explained by the difference in the data. If the cost of the staples basket with wider coverage of goods and cities were used for 1994–2000, the integration pattern would become worse. Gluschenko (2009, Figures 5 and 6) provides an indirect confirmation of this hypothesis. The degree of market segmentation estimated with the use of the 33-staples basket is higher than that estimated with the use of the 25-staples basket. One more hypothetical reason is the effect of the 1998 financial crisis in Russia. It caused structural breaks in many time series of price differentials; the breaks were distributed over August 1998 through January 1999. Thus, the after-break time span is rather short, containing 22 to 29 points in time. This would have prevented revealing actual behavior of price differentials after the break that differed significantly from the ‘pre-break’ behavior, overstating the ‘integration rate.’

However, these factors could provide only partial explanation. In general, reasons of poorer integration in 2001–2015 as compared with 1994–2000 are unclear. This relates specifically to the disintegration tendency stretching over more than a tenth of region pairs in 2001–2015. More detailed and deeper study is needed to explain reasons behind the obtained pattern of market integration.

6. Conclusion

Using the cost of the basket of 33 basic food goods as the price representative, the spatial pattern of market integration in Russia in 2001–2015 was analyzed. It was found that about 71% of region pairs in Russia could be deemed integrated or conditionally integrated, and about 5% could be classified as tending towards integration with each other. An unpleasant feature in the pattern obtained is a significant share (11%) of region pairs inclined to disintegration, i.e. exhibiting price divergence.

There are a number of poorly integrated regions in the European part of Russia. This seems strange from the viewpoint of their favorable geographical positions. Intuitive considerations suggest that market integration in Russia in 2001–2015 should be stronger than in 1994–2000, when transition from centrally-planed to market economy was in progress. Surprisingly, this has not been confirmed. Further research has to find explanation of this fact as well as reasons for incomprehensible features of the pattern obtained.

Acknowledgements

The helpful comments of participants at the conference “Spatial Analysis of Socio-Economic Systems: History and Current State” (Novosibirsk, 2016) and the Third Russian Economic Congress (Moscow, 2016) are gratefully acknowledged. Thanks are also due to Natalia Budkina for research assistance.

Appendix. Technical details of unit root testing

For testing the unit root hypotheses, H_λ, the *t*-statistic of λ is used, $\tau = \lambda/\sigma_\lambda$ (it has nonstandard distributions and is therefore denoted τ, and not *t*). Two tests employed take account of possible autocorrelation of a form other than AR(1). To do so, the augmented Dickey-Fuller (ADF) test uses an auxiliary regression which includes additional lags of the dependent variable. The Schwarz information criterion serves for choosing the optimal lag length. To choose it, the lag length varies from 0 to $K_{\max} = [12(T/100)^{1/4}]$, where [·] stands for integer part, while the number of included observations remains constant and equals $T - 1 - K_{\max}$ according to Ng and Perron (2005). Then the reestimation of auxiliary regression with the optimal number of lags and actual number of observations yields the adjusted value of λ and, in turn, τ which is tested for significance as $p(\tau) \leq \pi^*$, where $p(\tau)$ is the (cumulative) probability function, and π^* is an adopted significance level (0.1 in this study). Note that the auxiliary regression is purely technical, used only for obtaining adjusted value of τ; the estimates of λ and other regression parameters should be taken from the original regression. In the Phillips-Perron test, the Phillips (1987) transformation is applied, using the Newey-West (1994) automatic bandwidth selection method with the Bartlett spectral kernel. In contrast to the ADF test, this transformation adjusts value of σ_λ rather than λ.

Although distributions $p(\tau)$ are nonstandard, they are documented in the literature (e.g., MacKinnon, 1996) for the cases of Equations (5) and (6) as well as for equations with a linear and quadratic trends. These distributions (known as the Dickey-Fuller distributions) are built-in tool of different econometric packages. As for Equation (7) with different nonlinear trends, there are no ready-to-use distributions. To derive them, the empirical distributions of τ under the null hypothesis of random walk have been estimated with the use of the Monte Carlo method with 1,000,000 replications. Table A1 reports selected critical values of the τ-statistics for Equation (7) with trends (8a)–(8c) and sample size $T = 180$. Figure A1 plots the 10-percent tails of the distributions, comparing them with the Dickey-Fuller distributions for the cases of linear and quadratic trends.

Table A1. Critical values of the unit root test τ-statistics for Equation (7)

Significance level	Log-exponential trend (8a)	Exponential trend (8b)	Fractional trend (8c)
0.1%	–4.528	–4.463	–6.616
1%	–3.848	–3.865	–5.162
5%	–3.230	–3.279	–3.825
10%	–2.908	–2.974	–3.302
20%	–2.522	–2.614	–2.796

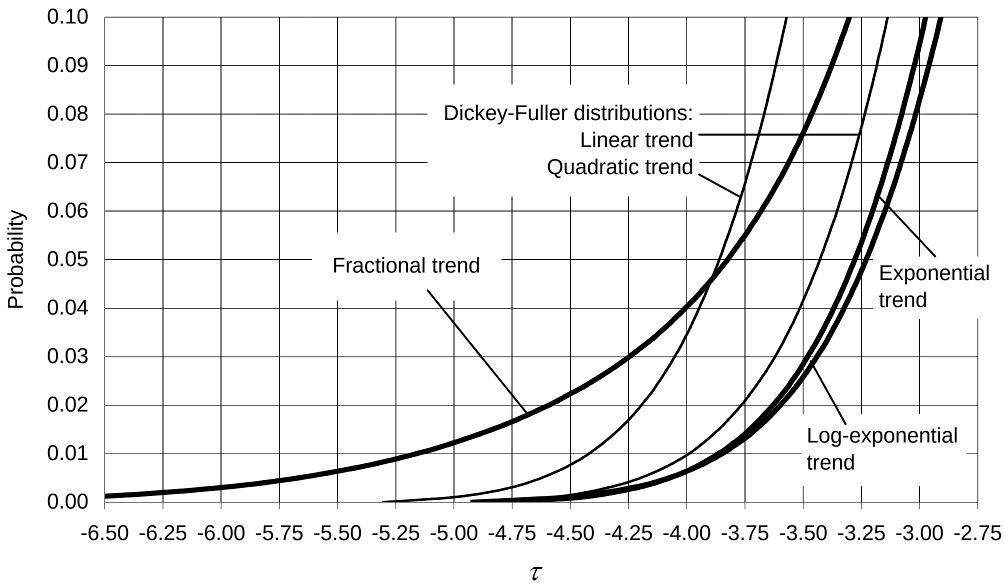


Figure A1. Distributions of τ-statistics for Equation (7).

References

Akhmedjonov, A., Lau, C.K. (2012) Do energy prices converge across Russian regions? *Economic Modelling*, 29: 1623–1631.

Berkowitz, D., DeJong, D. N., Husted, S. (1998) Quantifying price liberalization in Russia. *Journal of Comparative Economics*, 26: 735–760.

Ceglowski, J. (2003) The law of one price: intranational evidence for Canada. *Canadian Journal of Economics*, 36, 373-400.

Gardner, B., Brooks, K.N. (1994) Food prices and market integration in Russia: 1992-1994. *American Journal of Agricultural Economics*, 76: 641–666.

Gluschenko, K. (2009) Goods market integration in Russia during the economic upturn. *Post-Communist Economies*, 21, 125–142.

Gluschenko, K. (2010) Anatomy of Russia's market segmentation. *Economics of Transition*, 18, 27–58.

Gluschenko, K. (2011) Price convergence and market integration in Russia. *Regional Science and Urban Economics*, 41: 160–172.

Goodwin, B.K., Grennes, T.J., McCurdy, C. (1999) Spatial price dynamics and integration in Russian food markets. *Policy Reform* 3: 157–193.

Lau, C.K., Akhmedjonov, A. (2012) Trade barriers and market integration in textile sector: evidence from post-reform Russia. *Journal of the Textile Institute*, 103: 532–540.

MacKinnon, J. G. (1996) Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics*, 11, 601-618.

Newey, W., West, K. (1994) Automatic lag selection in covariance matrix estimation. *Review of Economic Studies*, 61, 631-653.

Ng, S., Perron, P. (2005) A note on the selection of time series models. *Oxford Bulletin of Economics and Statistics*, 67, 115-134.

Phillips, P.C.B. (1987) Time series regression with a unit root. *Econometrica*, 55, 277–301.